Results of Collimator Machine Protection Commissioning
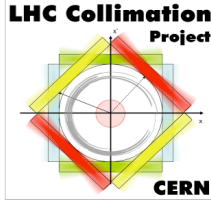
Stefano Redaelli, AB-OP

one behalf of the Collimation team
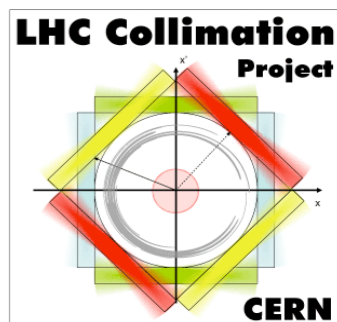
Outline

☑ **Introduction / procedures**

☑ **Positioning interlocks**

☑ **Special devices**

☑ **Temperature interlocks**

☑ **Outlook**

Introduction

☑ Overall strategy for the commissioning of collimator MP functionality defined in EDMS document

☑ Detailed procedure outlined and implemented in the application software

☑ Operational procedures documented and "handed-over" to OP team

MPS Commissioning Procedure

THE COMMISSIONING OF THE LHC MACHINE PROTECTION SYSTEM

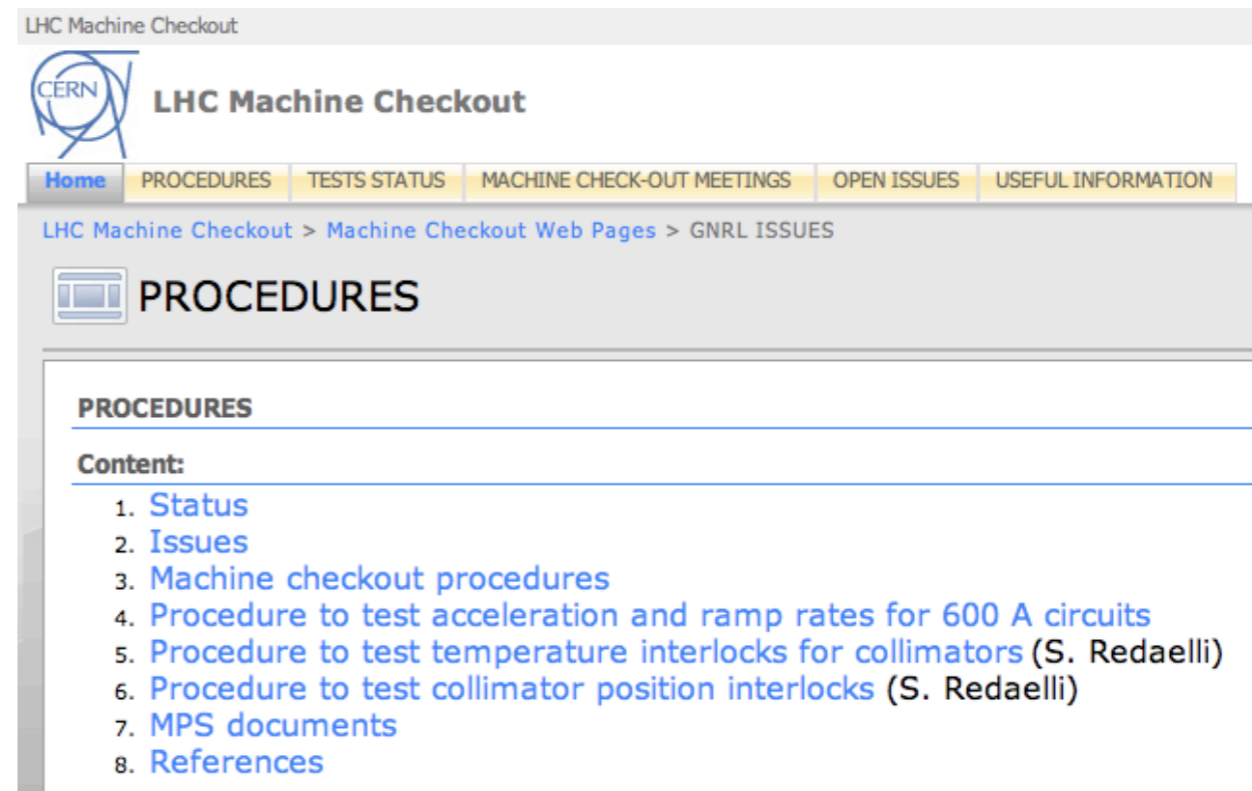**MPS ASPECTS OF THE COLLIMATION SYSTEM COMMISSIONING**

Abstract

This document describes the set of tests which will be carried-out to validate for operation the machine protection aspects of the **LHC collimation system**. The area concerned by these tests extends over 7 out of the 8 long straight sections.

These tests include the Hardware Commissioning, the machine check-out and the tests with beam, to the extent that they are relevant for the machine protection functionality of collimation.
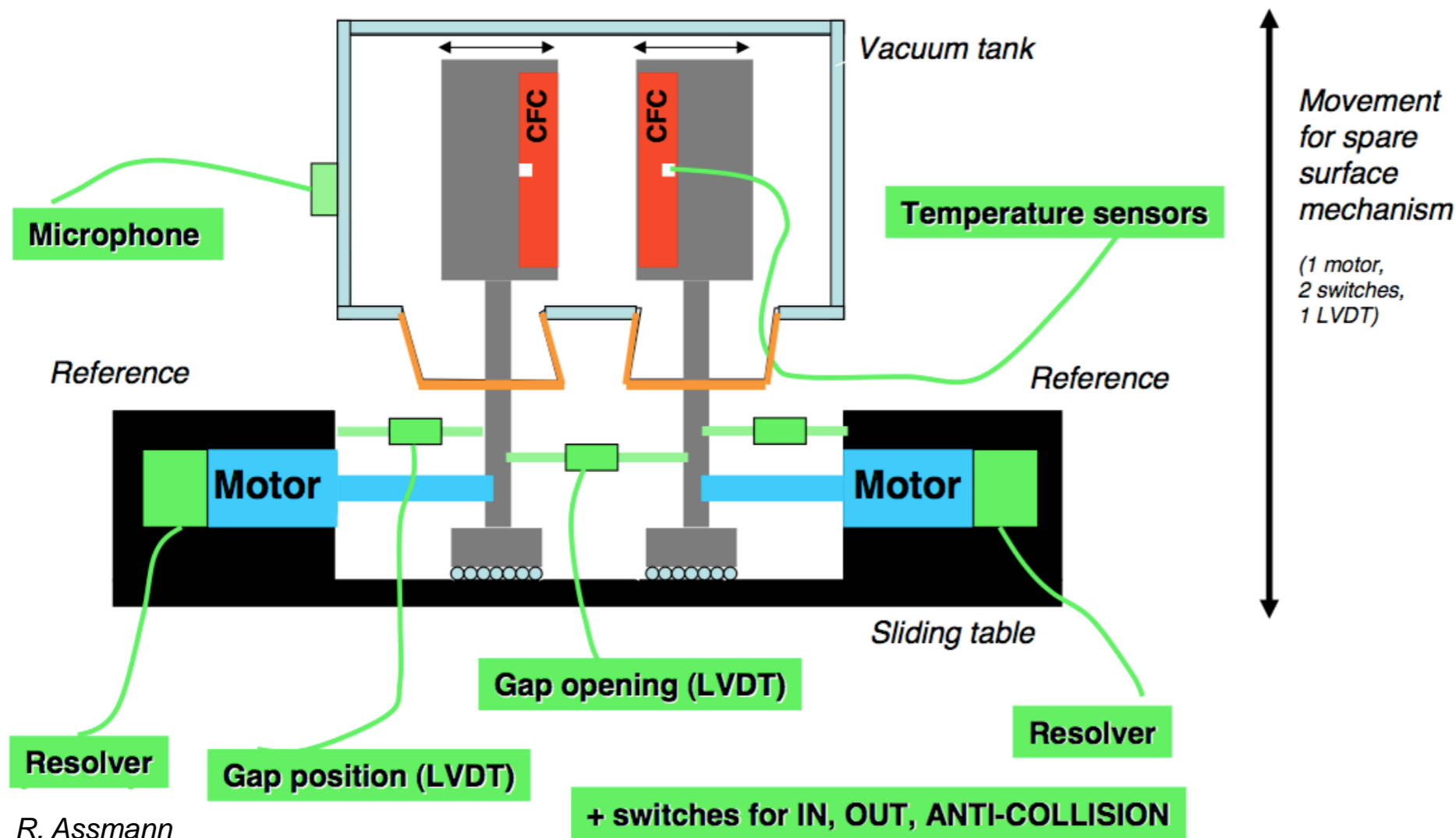
Prepared by :	Checked by :	Approved by :
Ralph Assmann Michel Jonker Roberto Losito Stefano Redaelli Thomas Weiler	Roger Bailey Andy Butterworth Bernd Dehning, Brennan Goddard, Eva Barbara Holzer, Verena Kain, Mike Lamont,	Rüdiger Schmidt

LHC Machine Checkout

LHC Machine Checkout

Home | PROCEDURES | TESTS STATUS | MACHINE CHECK-OUT MEETINGS | OPEN ISSUES | USEFUL INFORMATION

LHC Machine Checkout > Machine Checkout Web Pages > GNRL ISSUES

PROCEDURES

PROCEDURES

Content:
1. Status
2. Issues
3. Machine checkout procedures
4. Procedure to test acceleration and ramp rates for 600 A circuits
5. Procedure to test temperature interlocks for collimators (S. Redaelli)
6. Procedure to test collimator position interlocks (S. Redaelli)
7. MPS documents
8. References

OP procedures for MP test documented on the OP checkout page:
https://espace.cern.ch/LHCMachineCheckout/Machine%20Checkout%20Web%20Pages/GNRL%20ISSUES.aspx?PageView=Shared

Collimator positioning survey

R. Assmann

2008 system: 76 collimators + 2 TCDQ s + 2 TDI s

Full system: ~400 degrees of freedom ~2000 limit functions

Settings: 2 jaws → 4 motor positions; 1 motor for tank position.

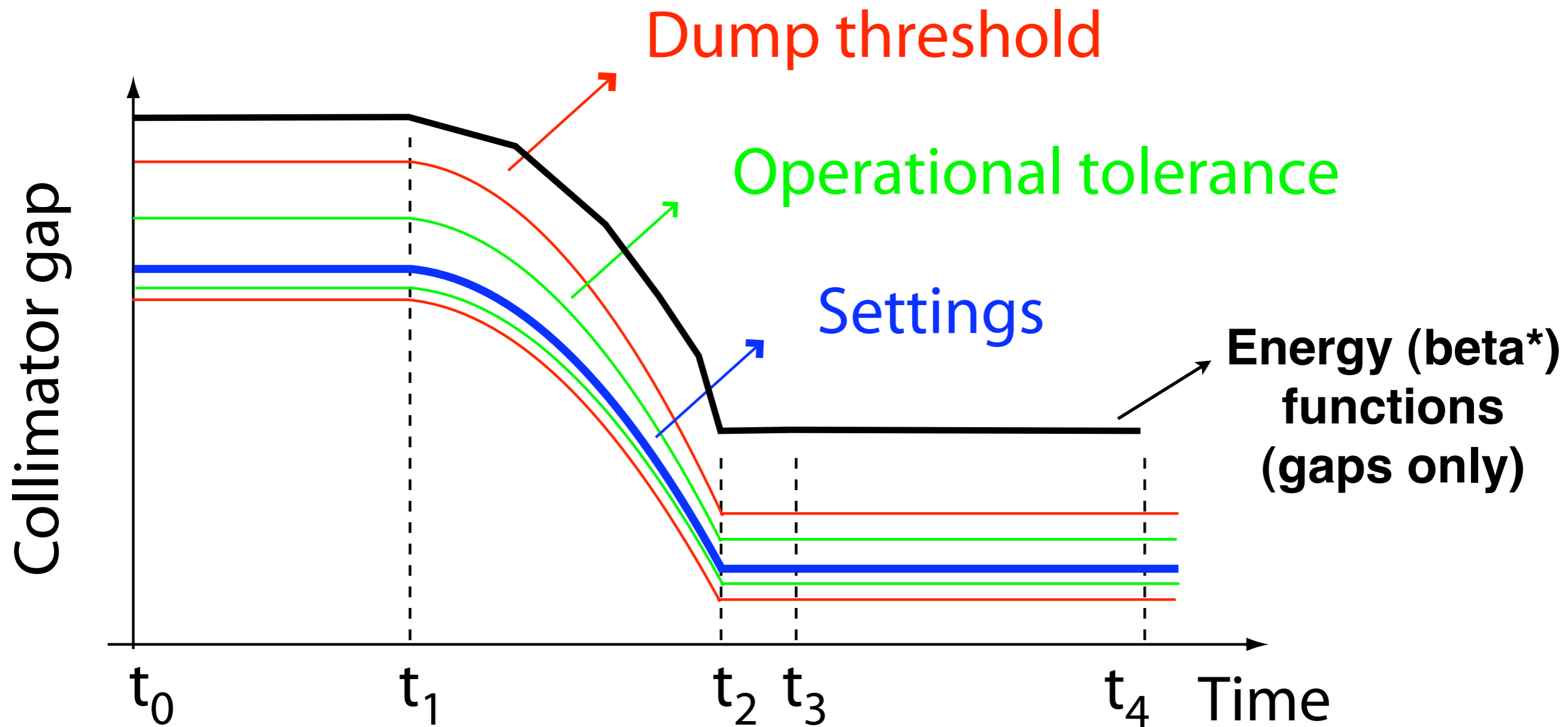Survey: 7 position measurements (4 corners + 2 gaps + tank)

4 motor resolvers

10 switch statuses (full-in, full-out, anti-collision)

Dump thresholds (functions+discrete): 6 x 2 jaw positions/gaps; some gap values vs. energy and beta* factor; 5 temperatures; switch statuses vs. machine mode.

S. Redaelli, MPP 15/10/2008

Position interlocking strategy

Dump threshold

Operational tolerance

Settings

Energy (beta*) functions (gaps only)

Collimator gap

t_0 t_1 t_2 t_3 t_4 Time

- ☑ Two regimes: discrete ("actual") and time-functions
    Both use the same internal clock at 100 Hz for comparison
- ☑ Time-limit functions for each motor axis + for gap measure
- ☑ "Double protection" → BIC loop broken AND jaw stopped
- ☑ Energy- (beta*-)limit functions only for gap (no frequent change)

Sequence for MP validation
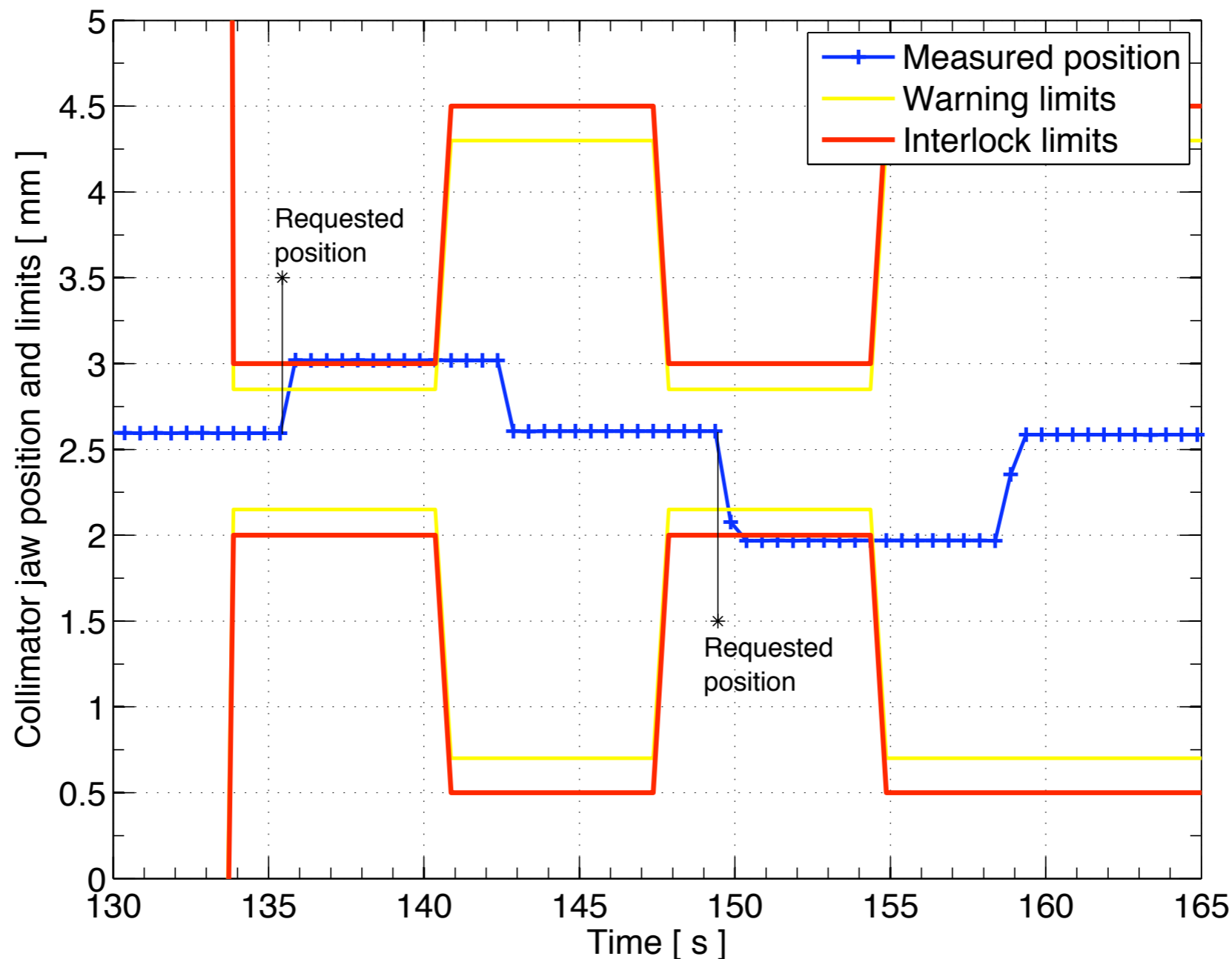
Example for 1 degree of freedom

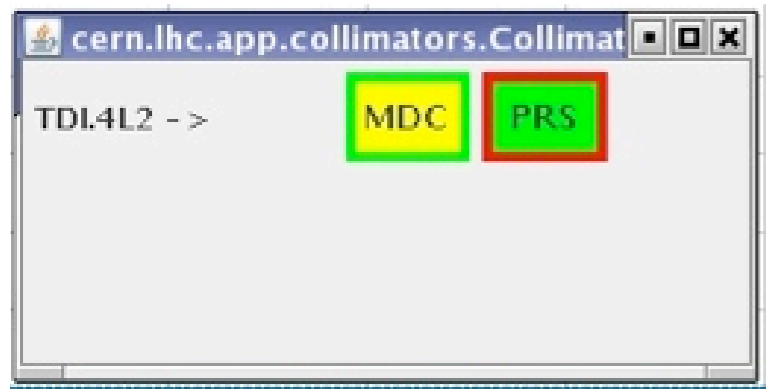Sequence implemented in the collimator application software:

"Hit" 12 interlock limits (inner+outer for 6 LVDT's) as well as 12 warning functions

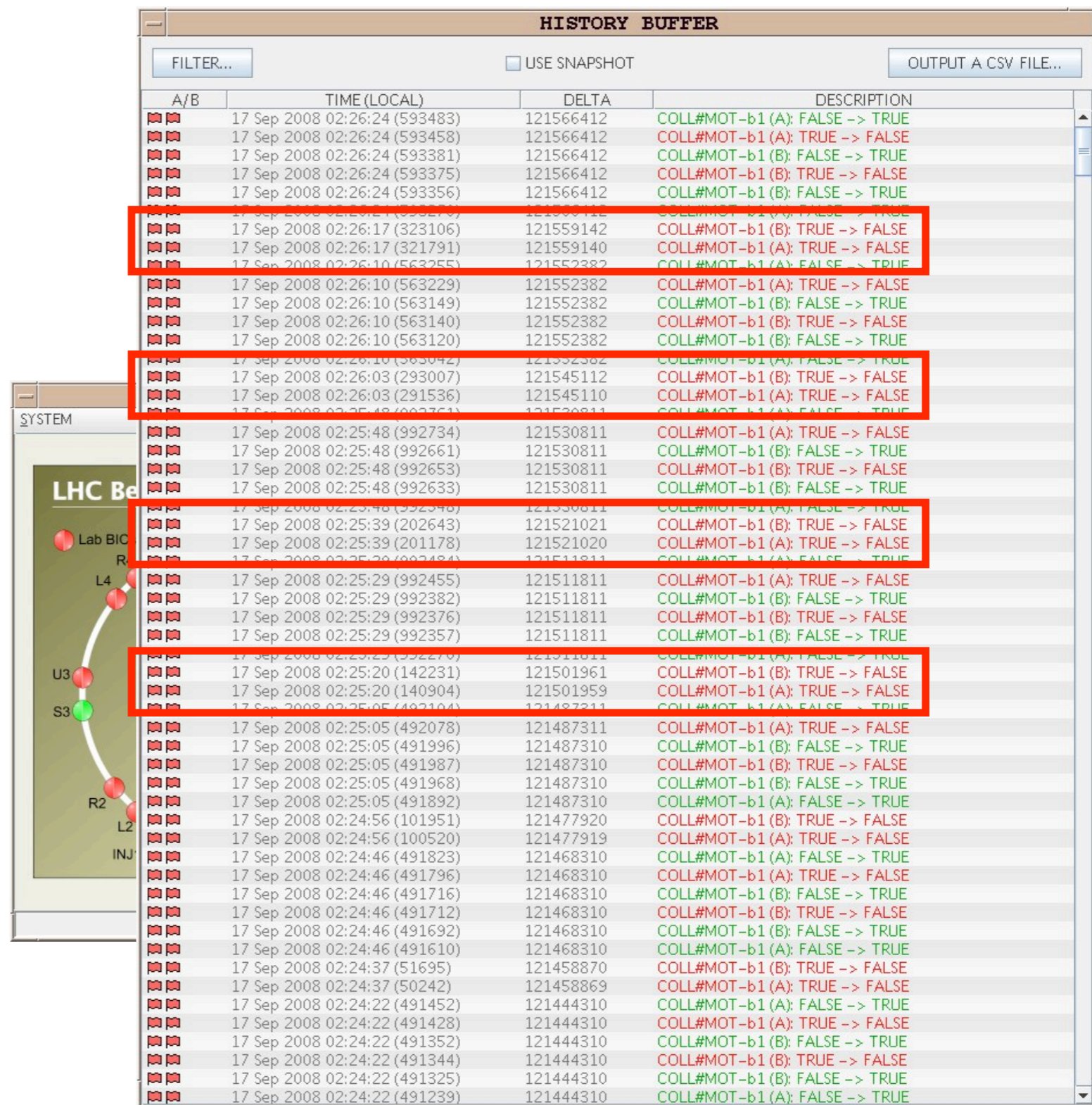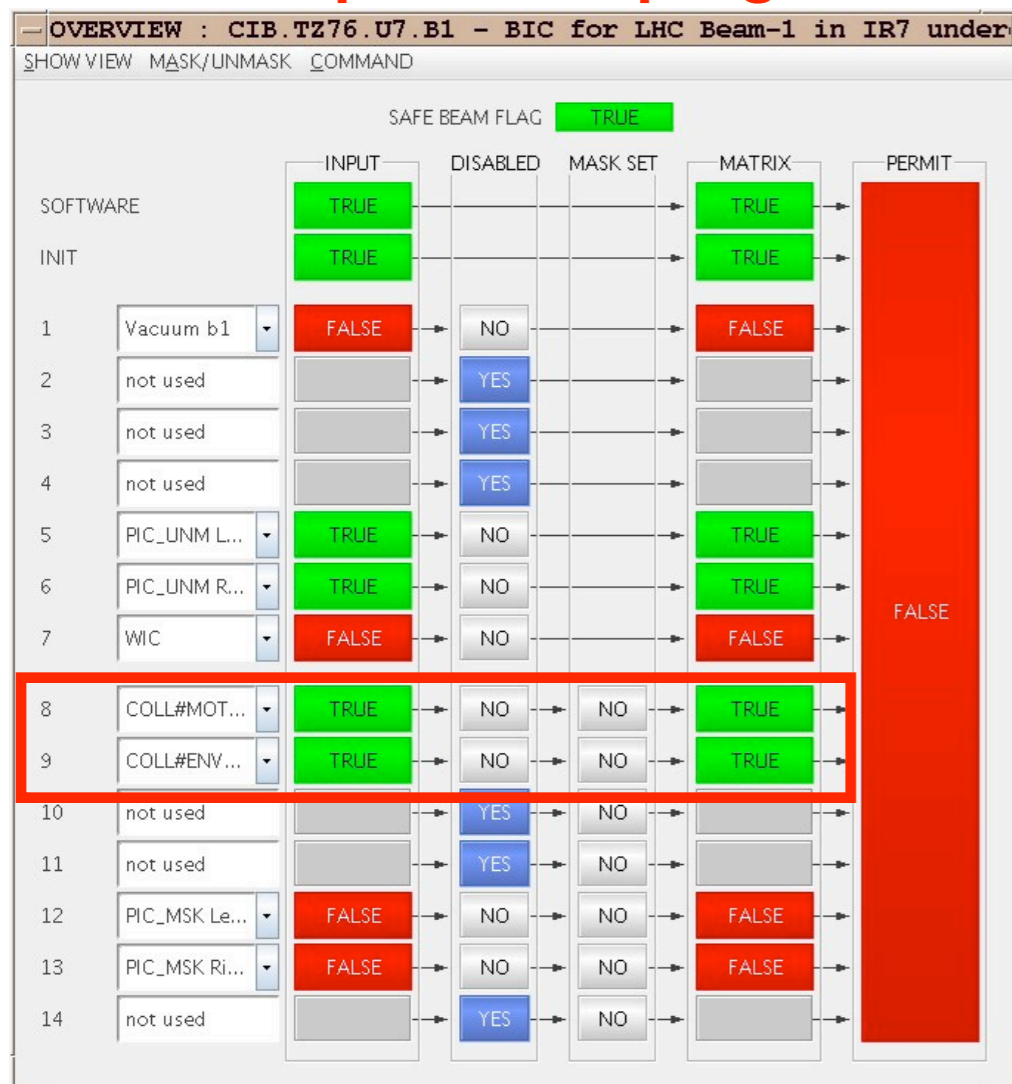"Hit" the 2 limits of maximum gap values versus energy

Monitor on-line: (1) collimator status and (2) status of collimator BIC input

It takes less than 5 minutes; Can be applied to many collimators on different BIC's
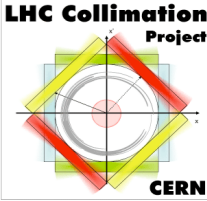
On-line status monitoring (I)

Collimator status display

BIC supervision program

BIC history buffer

```
....
CIB.UJ33.U3.B1,False False,17 Sep 2008 02:26:10 (563255),1221611170563255,121552382,COLL#MOT-b1 (A): FALSE -> TRUE
CIB.UJ33.U3.B1,False False,17 Sep 2008 02:26:10 (563149),1221611170563149,121552382,COLL#MOT-b1 (B): FALSE -> TRUE
CIB.UJ33.U3.B1,False False,17 Sep 2008 02:26:03 (293007),1221611163293007,121545112,COLL#MOT-b1 (B): TRUE -> FALSE
CIB.UJ33.U3.B1,False False,17 Sep 2008 02:26:03 (291536),1221611163291536,121545110,COLL#MOT-b1 (A): TRUE -> FALSE

CIB.UJ33.U3.B1,False False,17 Sep 2008 02:25:48 (992761),1221611148992761,121530811,COLL#MOT-b1 (A): FALSE -> TRUE
CIB.UJ33.U3.B1,False False,17 Sep 2008 02:25:48 (992661),1221611148992661,121530811,COLL#MOT-b1 (B): FALSE -> TRUE
CIB.UJ33.U3.B1,False False,17 Sep 2008 02:25:39 (202643),1221611139202643,121521021,COLL#MOT-b1 (B): TRUE -> FALSE
CIB.UJ33.U3.B1,False False,17 Sep 2008 02:25:39 (201178),1221611139201178,121521020,COLL#MOT-b1 (A): TRUE -> FALSE

CIB.UJ33.U3.B1,False False,17 Sep 2008 02:25:29 (992484),1221611129992484,121511811,COLL#MOT-b1 (A): FALSE -> TRUE
CIB.UJ33.U3.B1,False False,17 Sep 2008 02:25:29 (992382),1221611129992382,121511811,COLL#MOT-b1 (B): FALSE -> TRUE
CIB.UJ33.U3.B1,False False,17 Sep 2008 02:25:20 (142231),1221611120142231,121501961,COLL#MOT-b1 (B): TRUE -> FALSE
CIB.UJ33.U3.B1,False False,17 Sep 2008 02:25:20 (140904),1221611120140904,121501959,COLL#MOT-b1 (A): TRUE -> FALSE

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CIB.UJ33.U3.B1,False False,17 Sep 2008 02:25:05 (491996),1221611105491996,121487310,COLL#MOT-b1 (B): FALSE -> TRUE
CIB.UJ33.U3.B1,False False,17 Sep 2008 02:24:56 (101951),1221611096101951,121477920,COLL#MOT-b1 (B): TRUE -> FALSE
CIB.UJ33.U3.B1,False False,17 Sep 2008 02:24:56 (100520),1221611096100520,121477919,COLL#MOT-b1 (A): TRUE -> FALSE

CIB.UJ33.U3.B1,False False,17 Sep 2008 02:24:46 (491823),1221611086491823,121468310,COLL#MOT-b1 (A): FALSE -> TRUE
CIB.UJ33.U3.B1,False False,17 Sep 2008 02:24:46 (491716),1221611086491716,121468310,COLL#MOT-b1 (B): FALSE -> TRUE
CIB.UJ33.U3.B1,False False,17 Sep 2008 02:24:37 (51695),1221611077051695,121458870,COLL#MOT-b1 (B): TRUE -> FALSE
CIB.UJ33.U3.B1,False False,17 Sep 2008 02:24:37 (50242),1221611077050242,121458869,COLL#MOT-b1 (A): TRUE -> FALSE
....
```
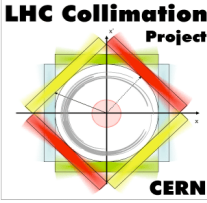
Thanks to Alick + BIC team for the implementation of the buffer history in text format.

Documentation of results (I)
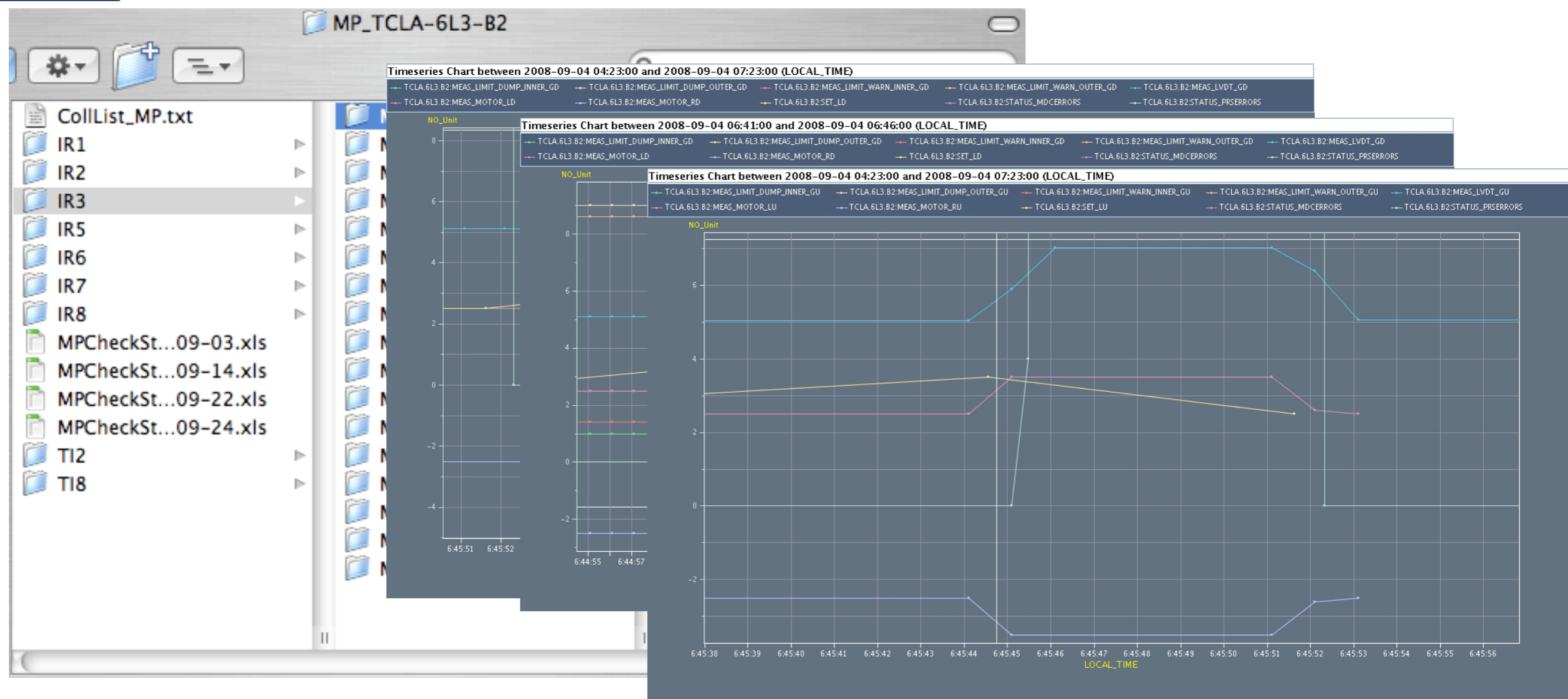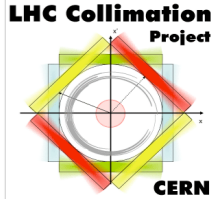

All sequences recorded in the permanent logging database

*Pre-defined sets of **logged variable lists** for a "fast" analysis of the sequence results!*

Special thanks to R. Billen and C. Roderick

Documentation of results (II)

☑ ALL logged data are SYSTEMATICALLY extracted as images for each sequence successfully run.

☑ Original plan: put this in MTF as a commissioning step together with data from BIC history

☑ Will prepare a web page to document the results of 2008 system

Summary of results

- ✓ **All collimators tested; status file maintained as followup**
- ✓ **Overall: very satisfactory, no major issues encountered**
- ✓ **Focused on discrete limits so far**
- ✓ **List of problems encountered:**
  - TCDIH.20607 not connected to BIC
  - *Few energy limit checks missing in IP3*
  - *1 gap value in TI8 badly calibrated - could not run sequence for gaps*
  - *Early on, found two collimators where MP functionality was NOT activated after calibration (very dangerous!)*
- ✓ **Tests of function limits systematically done for a few cases**
- ✓ **Ready to start global tests, synchronized with other accelerator systems (ramps PC's, final Energy ditribution)**

Check of function limits
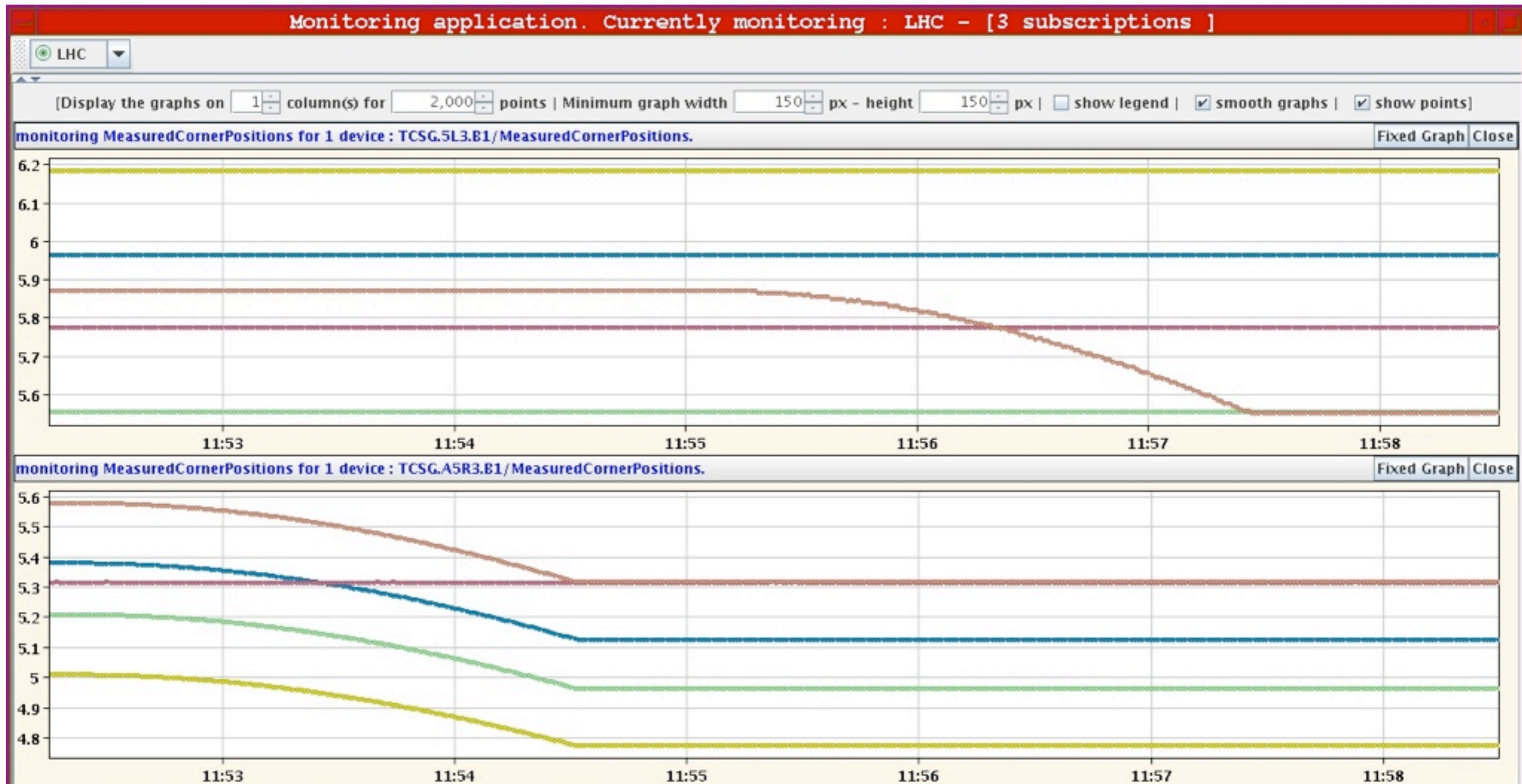
Individual system test done for the function-based limits (time- and energy-dependent) as a part of IST s

Outline

☑ Introduction / procedures

☑ Positioning interlocks

☑ **Special devices**

☑ Temperature interlocks

☑ Outlook

TCDQ positioning interlock

☑ Same basic functionality but different hardware and software

 One-sided elements (2 position measures), no gap measurements
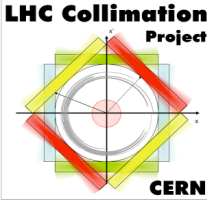 *Different low-level controls: servo-loop based on potentiometers*
 Same LVDT s as collimators added for interlocking purpose
 Not yet energy limits possible (under discussion)

☑ Defined a middle-level FESA interface to minimize impact

 Could re-use most of the tools, including logging!

☑ Sequence for discrete limit checks run manually (only 4 LVDT's). Successful!

☑ Function limits not yet opera-tional as of 3 weeks ago
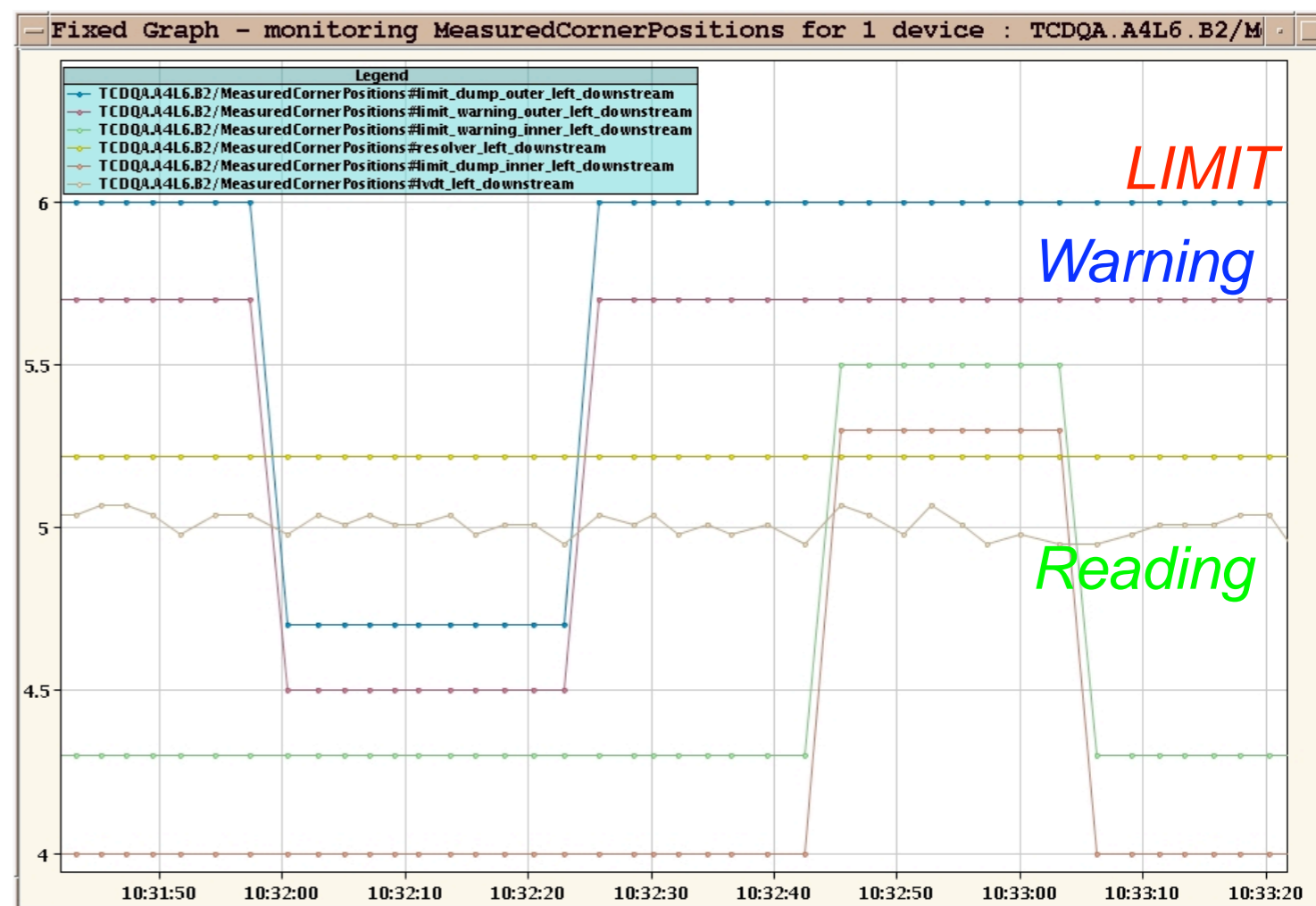
Full chain tests done with C. Boucly, E. Carlier

TDI positioning interlock

☑ Different hardware but basically same software

> *Missing direct gap measurements*
>
> *No need of energy limits*

☑ Important difference: connection also to injection BIC

☑ Special interlock implementation:

> OUTER limits for injection permit (Don't inject if OUT)
>
> INNER limits for circulating beam permit

☑ Implemented but first tests failed because wrong sensors were connected to BIC (2 LVDT's per motor axis)

☑ Will repeat that as soon as this is fixed

Temperature interlocks

☑ UNYCOS system under PVSS (E. Blanco)

☑ 4 sensors per jaw + 1 for cooling water: 403 sensors for 2008 system

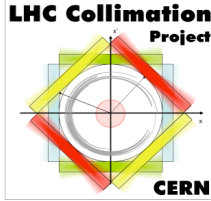☑ All sensors connected to BIC, INDIVIDUAL dump + warning limits

☑ Cannot heat the sensors. Forced the temperature reading to check the functioning of the interlock chian.
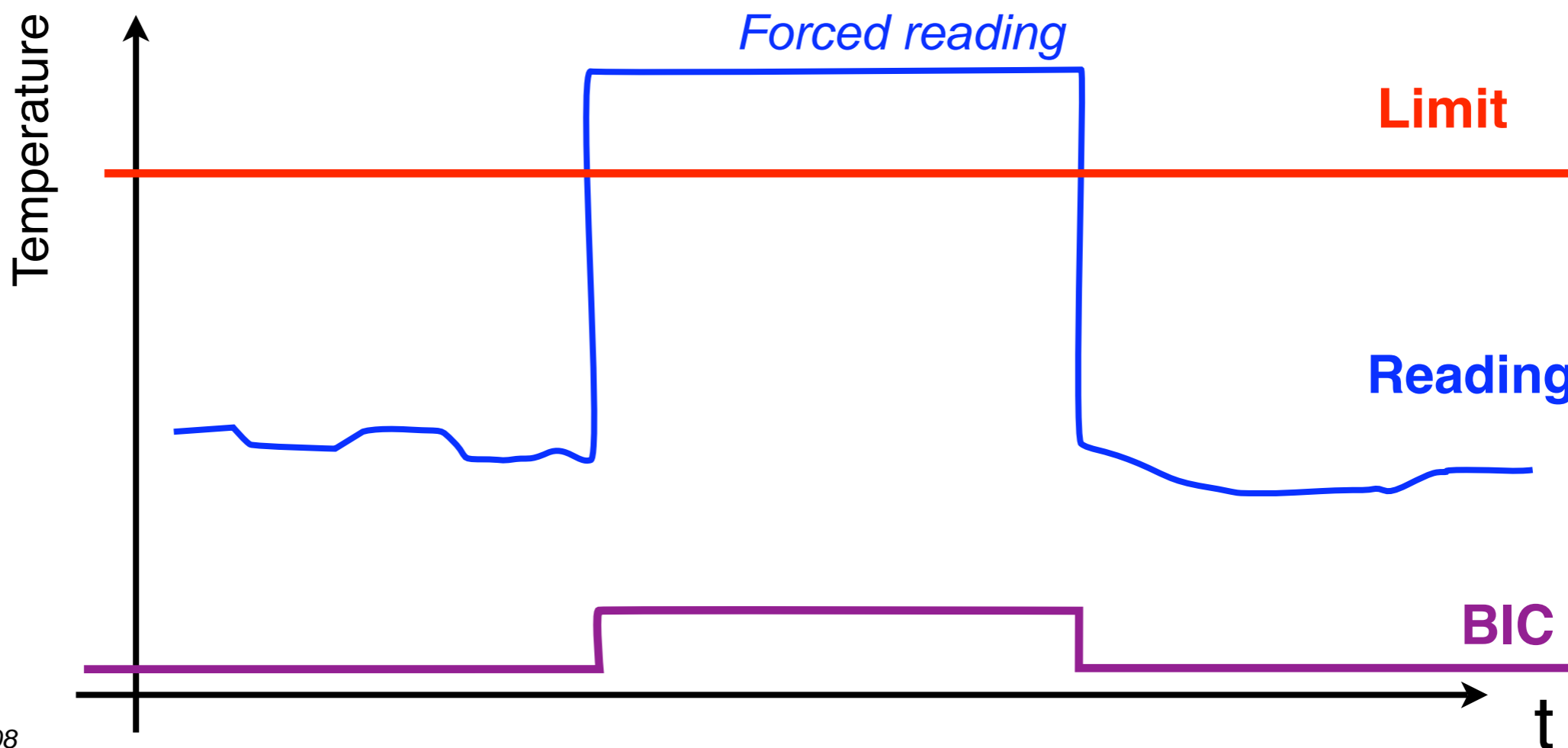
Temperature interlocking - summary

☑ Verified individually all 400 sensors *(thanks Delphine, Eric)*

☑ Overall: no major problems, system works very well

☑ A few punctual problems submitted to Quique:

    4 problems found. A couple of dead sensors.

☑ Need to work on the sensor calibration

    Sensor readouts are not always as expected.

☑ **Special elements: TCDQ, TDI**

    Reading available from FESA (provided by BT/ATB)

    Different control chain. Interlocks not yet implemented.

    If interlocks needed, propose to have the same FESA

    interface for limits for both, to be implemented.

Conclusions / Outlook

☑ Machine protection tests for the collimation system was basically completed

☑ Tests were very useful and successful
 Few problems encountered, minor list of TODO s

☑ Confident that the system provides the functionality that it was designed for!

☑ Outlook:
 Interlocks from switch statuses not tested for all colls
 Automatize the analysis?
 Implementation of TCDQ energy limits
 Roman pot interlocking (a whole chapter...)
 Systematic MCS tests for the full system
 Follow-up the implementation of beta*-limit functions
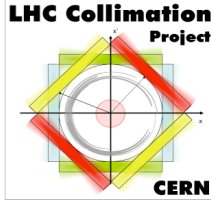 *Setting reproducibility tests to define the limit windows*

Results of reproducibility tests
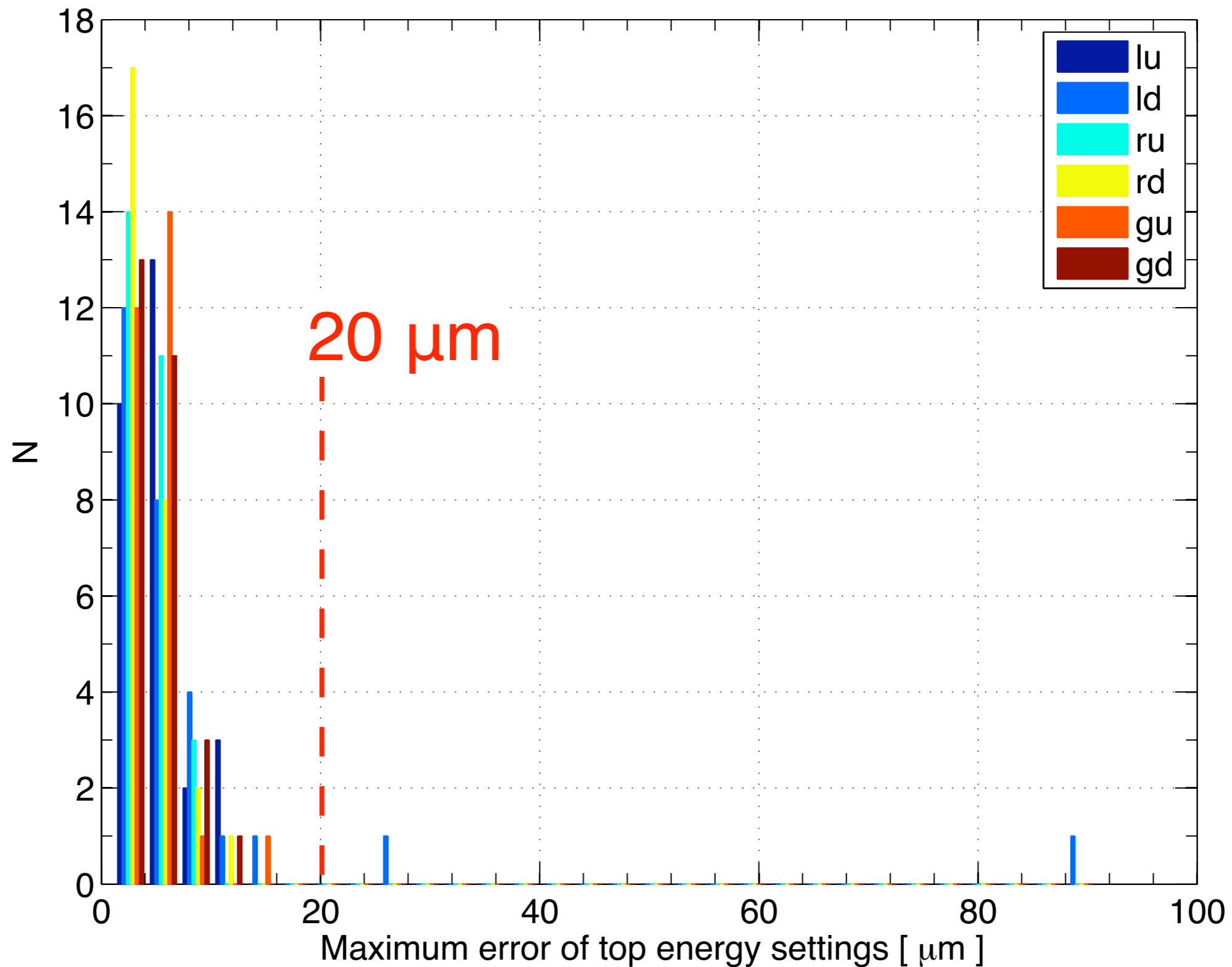
Setting reproducibility errors for 28 collimator in IP7 (168 LVDT s).
Performed about 20 nominal ramp functions to 5 TeV.

Acknowledgments

- ☑ Work of MANY people from the collimation team, in particular the ATB control team

- ☑ Ralph, Joerg, Ruediger; INJ + DUMP teams; Gianluigi

- ☑ Quique Blanco for all the temperature controls

- ☑ Bruno's team

- ☑ Thanks to R. Billen, C. Roderick + logging team

- ☑ LHC operation crew deeply involved in the tests for

  Running sequences (Markus, Fabio, ...)

  Analyzing sequence results (M, F, Reyes, Funny, ...)

  Checking temperature interlocks (Delphine, Eric)